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Speaking Their Language: Does Environmental Signage Align to Personal Dimensions of Environmentally Responsible Behavior in Undergraduate Residence Halls?

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Abstract: Everyday environmental behaviors within the residential sphere contribute significantly to global carbon emissions. Understanding the factors underlying these behaviors is key to changing behavior. This paper examines undergraduate behavior in on-campus housing as a case study with the following aims: (1) to identify the personal dimensions that underlie undergraduates' environmentally responsible behaviors (ERBs) and (2) to determine if environmental signage in on-campus housing aligns with these existing personal dimensions. This study involved an online survey of ERBs, values, motivations, and knowledge of students in six residence halls. A content analysis of environmental signage examined how values and motivations were used to frame environmental messages. Comparisons were made to determine how the communications aligned to occupants' values and motivations. Undergraduate ERBs are supported by subjects' Biospheric values, Environmental Concern, and motivation to engage with Technology. Female subjects performed significantly more ERBs than male students. Male students placed a significantly higher value on Egoism, which was significantly associated with poorer environmental behaviors. Signage with behavioral appeals is a relatively cost-effective and prevalent intervention strategy. However, signage should be tailored to appeal to a range of values and motivations of the target audience, including students' desires to interact with technology and the personal benefits of environmental responsibility.

Keywords: environmentally responsible behavior; behavior change; intervention strategies; signage; prompts; residence halls; message framing

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1. Introduction

The capacity of human behavior to mitigate global sustainability challenges is significant. It has been estimated that changing a few daily behaviors (e.g., reducing personal travel by automobile, lowering thermostats in the winter, and line-drying one's clothes) could add up to an overall greenhouse gas reduction by 20% over the next ten years [1]. However, shifting deeply habitual behaviors necessitates addressing a complex array of psychological, social, and situational factors that shape human behavior. Better understanding the key factors underlying environmental behaviors in multiple contexts is the first step in affecting behavioral change.

One appropriate context to study the cultivation of environmentally responsible behaviors (ERBs) is the college campus. Universities represent complex networks of intersecting institutional, pedagogical, and structural sustainability initiatives. This network has been described as a "whole-system approach to sustainability" [2,3], and the life of the on-campus college student is deeply embedded within this system.

Recent consumer science and human resources research indicates that as a generation, current traditional undergraduate students prioritize concern for the environment above other causes in making purchasing decisions and in choosing companies for which to work [4,5]. Though much research has examined the efficacy of various strategies to promote ERBs within this population [6–10], we presently know relatively little about the

psychological underpinnings of this population's environmental behaviors. This paper contributes to the larger sustainability discussion of the psychology of behavior change through the lens of a case study that examines the ERBs of undergraduates in sustainable on-campus housing. The two research questions explored in this paper are: What personal dimensions predict undergraduate Energy, Water, and Materials conservation behaviors within campus residence halls (RQ1)? Furthermore, does the language employed in environmental signage within residence halls align to the existing personal dimensions of undergraduate ERBs (RQ2)? This paper provides a brief literature review on the factors associated with ERBs and the use of signage as a behavioral intervention. The methods section discusses the use of an online survey to measure students' ERBs, knowledge, values, and motivations, as well as the use of photographs of building signage to determine how behavioral appeals are framed in signage language. The results identify the key personal dimensions associated with students' ERBs and whether signage language aligns with these personal dimensions. Recommendations to improve the alignment of messaging frames to the diversity of factors underlying environmental behaviors will be made.

1.1. What Are the Personal Dimensions Associated with College Students' ERB?

The psychology of behavior change is multidisciplinary. Situated in the literature on public health, social work, and environmental stewardship, among others, there is cross-disciplinary consensus regarding the constructs that drive human behavior (e.g., [11–13]). In general, knowledge is considered paramount to intentional behavior and is included in several foundational models [14–19]. Kaiser and Fuhrer [17] identify three forms of knowledge that support different phases of behavior change. Declarative knowledge describes an issue and cultivates awareness that a problem exists. Procedural knowledge comprises the steps necessary to achieve goals and helps identify courses of action. Effectiveness knowledge pertains to the relative impact of different conservation behaviors. Previous work has suggested that behavioral appeals conveying only declarative information rarely result in behavior change because they fail to provide procedural and effective information to help people identify viable behavioral responses [17]. Thus, effective behavioral interventions should not only inform people about the nature of a problem but support them in building an understanding of the possible strategies for responding effectively to a given problem.

Though knowledge can support the adoption of conservation behaviors, increasing knowledge alone is rarely sufficient to change behavior [20–22] and may not result in durable behavior change [23]. Enduring behavior change often involves targeting a combination of other, more deeply rooted psychological constructs. A review of several behavior change models reveals factors such as values and motivations [19,24–29]—that form an individual's "mindset" or orientation toward the world—are often not easily manipulated by external stimuli such as information campaigns and incentives. However, researchers like Wynveen et al. suggest appealing to existing values and motivations, particularly to enhance the effectiveness of sustainable living programming among college students [30].

One challenge to targeting the values and motivations of college students is that within the environmental stewardship literature, there is not a clear understanding of which values and motivations are most salient within this population. Some recent studies have suggested that students living in on-campus residence halls are likely unmotivated to change energy and water consumption behaviors because they bear no financial responsibility for their consumption [31]. However, undergraduate students likely have compatible values, derived satisfactions, or previously developed understandings about the consequences of their actions that are compatible with conservation behavior. This is an important population to understand better, as this generation's environmental behaviors have the potential to significantly improve our environmental and climate prospects in the next decade or steer us further toward irreparable climate change [32]. The psychological factors that underlie conservation behavior in this population merit further study. Thus, the first question at the center of this study arises: What are the personal dimensions of undergraduates' environmentally responsible behaviors?

1.2. Signage as Environmental Behavior Intervention

The empirical literature on promoting ERB has focused on several interventions that can be implemented within the residence hall and applied to other contexts that constitute the scope of people's everyday lives. Social competition [33,34], social support [9], behavioral feedback [35,36], incentives [37], and goal-setting with commitments [7] have shown varying success, though the durability of behavior change remains a challenge.

Signage is a regular component of the "3D textbook" that comprises informal learning in residence halls [38], particularly in green buildings. Sustainable architecture is gaining popularity among college campuses [39] as green buildings contribute significant savings to campus carbon emissions and energy costs. Consequently, green buildings are frequently positioned as "living laboratories" for sustainability literacy on campus [40]. Signage is integral to this mission and is typically awarded innovation credits by the USGBC LEED green building rating system for implementing environmentally educational features [41].

Several recent studies have indicated that signage is the dominant way that green building features are communicated to building occupants [42–44]. Occupants' awareness of green building features is pertinent to the discussion here, as occupants' knowledge of green building features is positively related to their performance of ERBs within green buildings [45]. Recent work by the first author [46] demonstrated a connection between green building signage and occupants' ERBs in residence halls. Informational signage is thought to "prime" occupants' participation in eco-behaviors by communicating the sustainable ethos of the building. These findings bolster other work stating that green building atmospherics, or that a building is easily perceived as sustainable is supportive of ERBs [47,48]. Additionally, signage containing behavioral prompts was positively related to residents' material conservation behaviors in green residence halls [46]

As a cost-effective means of potentially shaping occupant educational and behavioral outcomes in green buildings, signage is increasingly prevalent. Yet, despite the consensus among green building scholars that signage may positively influence occupant ERBs, there is relatively little work informing evidence-based guidelines for behaviorally supportive signage. Some fundamental guidelines for effective signage emerge from designing effective prompts. From this literature are two clear directives: (1) Prompts should be located at the behavioral decision point (e.g., a prompt to turn off the lights should be located next to the light switch) and (2) Prompts should be clear and understandable (i.e., the desired behavior should be evident and unambiguous) [34,49].

Additionally, conceptualizing signage as a behavioral intervention may be informed by the literature on crafting persuasive messages, which cites the necessity of "framing" the message to appeal to the target audience [50–53]. *Framing* refers to a means of conveying information in a particular way in order to be more easily understood or accepted by a certain audience [51]. Environmental stewardship scholars have identified one of the central problems with many environmental appeals–they focus too much on the environment. Environmentally desirable behaviors may be motivated by a variety of underlying values and motivations [52], which underscores the need to better understand the determinants of college students' ERBs.

The current study aims to understand how existing signage in undergraduate residence halls frames behavioral appeals according to different values and motivations, as well as provide a variety of information to prompt participation in environmentally responsible behaviors. In other words, given the proliferation of educational signage used to interpret green building features and prompt undergraduates' ERBs in residence halls, is signage "speaking their language?".

In summary, the aims of this work are to explore the personal dimensions of undergraduate students' ERBs and to examine whether building signage designed to prompt ERBs frames behavioral appeals in alignment with these personal dimensions. Though this work examines the psychology of environmental stewardship through a case study lens of college students living in on-campus housing, the findings are useful for practitioners working with broader populations. Understanding how environmental behaviors are

"multiply determined" [23] within this case study translates to the need to understand better the underlying behavioral drivers of other specific populations and the necessity to craft persuasive messages that are personally relevant.

2. Materials and Methods

Promoting sustainable behavior necessitates adopting a "theory of science" perspective that acknowledges not only the role of psychological factors underlying ERB, but the complex interactions of environmental stimuli, social context, and previous experiences that affect environmental behavior decision making [54]. Thus, the present study involves a mixed method design that contributes one piece to the puzzle of better understanding the personal dimensions underlying ERBs and how to craft more supportive situational contexts to support desired behaviors. We explore two research questions (RQs): What personal dimensions predict undergraduate Energy, Water, and Materials conservation behaviors within campus residence halls (RQ1)? Furthermore, does the language employed in environmental signage within residence halls align to the existing personal dimensions of undergraduate ERBs (RQ2)? This study was a part of a larger project by the first author on how green building features can support occupant ERBs. Though the personal dimensions underlying occupant ERBs were included in the statistical models reported elsewhere [46], the companion study focused solely on making connections between the physical environment of green buildings and occupant ERBs. Thus, the findings regarding the predictors of occupant eco-behaviors are being presented for the first time, and the signage analysis included in this paper is novel.

2.1. Participants

The study involved an online survey of the behaviors, knowledge, values, and motivations of undergraduate students living in on-campus residence halls at two universities in the Midwest United States. All students who were first-time residents of their halls were invited to participate in the study, which included an online survey two times during the academic year.

2.2. Research Settings

The research settings were identified from a project database of U.S. Green Build Council LEED® certified undergraduate residence halls within a similar geographic area. The selected research settings were part of two large public universities in the Midwest United States with over 30,000 undergraduate students. At each university, two of the residence halls met the standards of LEED® Gold certification, while one residence hall was a conventional building.

The residence halls vary with respect to age, with the green residence halls built within the last ten years and the two conventional halls built in the 1950s with only minor renovations in finishes. However, despite the age of the buildings, the halls share many functional similarities. All provide shared rooms with communal spaces for lounging and socializing, studying, laundry, and computer facilities. Environmental communications across the residence halls consisted of a combination of permanently installed and post-hoc signage. Permanently installed signage served to identify sustainable features throughout the green buildings and instruct occupants about appropriate use (e.g., how to use a dual-flush toilet for water savings). Post-hoc signage was used throughout all six residence halls and often communicated behavioral prompts (e.g., turn off the lights when leaving a room, or turn off the faucet while brushing teeth).

2.3. Instrument: Online Occupant Survey

The purpose of the survey was to assess the personal dimensions of students' environmental behaviors. ERB was divided into three categories of conservation behavior (Energy, Water, and Materials). The survey was subdivided into sections based on each behavioral category and included a bank of questions about students' typical behavior relative to the

category, their perceived knowledge of green building features, perceived knowledge of relevant ERBs, motivations, and values. Demographic questions included the student's age, gender, nationality (domestic or international student), major, and year in school. The survey and all scripted communications with study participants were approved by the Institutional Review Board. Participants were informed that they could withdraw from the study at any time.

Students' knowledge was assessed through a combination of Likert scales and open-response questions. Declarative knowledge about climate change was assessed through a 5-point Likert scale (1 = Completely Disagree, to 5 = Completely Agree) that asked students to consider how much they agreed or disagreed with statements regarding the belief that the earth's climate is changing, the dominant causes of the changing climate, and an assessment of their ability to explain the topic of climate change to a friend. Climate change awareness was calculated via the mean of the items within this bank. Within each behavior category (Energy, Water, and Materials), students were asked to assess their own knowledge of the sustainable features of their residence hall and how much they knew about behaviors they could perform to conserve resources relative to the category. Students used a 5-point Likert scale (1= "Nothing" to 5 = "I know more than most of my peers") to indicate their Perceived knowledge of sustainable building features and Perceived knowledge of conservation behaviors.

The study included two banks of items that measured values and motivations. A wide variety of values and motivations have been shown to support ERB [19,28,29,55–57]. Stern's [19] Value-Belief-Norm theory of environmentalism suggests there are three dominant categories of values: social, biospheric, and egoistic. Social, or altruistic, values relate to the care for the well-being of others. As the environment is a public good, behaviors that protect and conserve the environment are viewed as an extension of how one cares for other people. Biospheric values refer to care for non-human nature. Lastly, egoistic, or self-enhancement, values have been empirically associated with lower ERBs [19]; however, other research suggests framing environmental messages to appeal to alternate values, such as self-protection, can be effective in cultivating ERBs [53]. A bank of 15 items derived from Stern's 3 values was created to measure students' values. The stem question asked students to consider how important or unimportant 15 statements were as guiding principles in their lives. Participants indicated the degree to which they endorsed each value statement by sliding a marker along a numeral scale ranging from 0 to 100, where 100 indicated the value was extremely important.

Motivations were assessed via a similarly structured bank of items where the stem question asked students to indicate how motivating a series of statements would be in encouraging them to participate in an activity. Students responded to the 28 items by sliding a marker along a scale ranging from 0 to 100, where 100 indicated that the item would be extremely motivating. The list of items was derived from the literature on motivations of ERB and participation in environmental stewardship programs [29,58,59]. In total, the list included items representing eight motivations identified from the literature: social belonging, personal well-being, care for the environment, participation in something meaningful, exploration or competence-building, frugality, spiritual growth, and having access to consumer goods and technology.

Students completed a self-assessment of their ERBs for each category based on the possible frequency of performing certain behaviors. The responses were documented on a 7-point Likert scale where 1 = Never, 4 = Sometimes, 7 = Always, and an eighth point was assigned for 'Not Applicable.' The instrument for this research was adapted from a longitudinal survey assembled by the University of Michigan [58,60] to map the environmental behaviors, attitudes, and values of faculty, staff, and students. The tailored survey instrument for this research consists of an average of nine items for each behavior category. Examples of energy conservation behaviors included turning off lights when leaving one's bedroom or using the power savings settings on one's computer. Water conservation behavior included items such as turning off the water while brushing one's

teeth and taking shorter showers. Materials conservation behavior contained measures of recycling and composting frequency and efforts to reduce consumption by purchasing second-hand items rather than buying new ones. Thus, though the context of this study involves undergraduate students in on-campus housing, the behaviors measured are applicable across a wider range of populations in other contexts. Excerpts from the survey pertaining to this study have been uploaded as Supplementary Materials.

2.4. Data Collection

2.4.1. Online Occupant Survey

The survey was created in Qualtrics, an online survey methodology tool, and distributed via a unique link per each residence hall to a single contact person at each university. University contacts distributed the survey link and invitation email to all first-time residents of the six target residence halls at two points in time during the academic year. The fall survey was distributed three weeks following the first day of classes at each University. The spring survey was distributed five months later. The surveys remained open for three weeks, during which students received two follow-up emails from the researcher, which were distributed by the campus contact. Participation was incentivized by entering participants' email addresses into a drawing for one of four $25 gift cards per residence hall in both the fall and spring semesters. To track individual student behavior over time, students were asked to create a unique password that they would use in both the fall and spring semester surveys. The use of the password to track behavior change will be discussed further in the Data Analysis section below.

2.4.2. Photo Documentation of Environmental Signage

The primary researcher toured all six residence halls shortly after completion of the first occupant survey and was accompanied by a facilities manager or university representative familiar with the features of the buildings. The researcher took photographs of all student-accessible spaces, including lobby and lounge spaces, study areas, laundry and computer facilities, trash and recycling rooms, and a sample resident room and bathroom. In addition to capturing a complete picture of the atmospherics offered in these green residence halls, the researcher intentionally documented all instances of signage containing green building interpretation (e.g., describing features of the sustainable building) and environmental behavior prompts.

2.5. Data Analysis

2.5.1. Constructs and Measures

The data were analyzed in IBM SPSS Statistics. Responses were eliminated for students who indicated they had lived in the residence hall prior to the study year. Additionally, participant responses were removed if they did not complete all sections of the survey. Each response was assigned a participant ID number; students who had provided a matching password on the T1 (fall) and T2 (spring) surveys were matched and given the same participant ID. Thus, participants 1–54 have data recorded for both the fall and the spring, and these students were recorded with the same Participant ID. A composite score of each behavior category (Energy, Water, and Materials) was calculated via the arithmetic mean of the survey items within each category.

A principal axis factor analysis with varimax rotation was conducted on the bank of 15 Values items for participants who took the survey at T1. Subjects were asked the stem question of how "important or unimportant each of the following items" was a "guiding principle" in their lives. The analysis produced three factors with eigenvalues above Kaiser's criterion of 1 [61,62], and together these explained 52.67% of the variance. Only one item ("Working for peace in the world") loaded above 0.45 on two factors and therefore was eliminated when new variables were created. Table 1 shows the factor loadings after rotation and the Cronbach's alpha for each factor. The items clustered under each factor represent the following value orientations: Biospheric (factor 1), Social (factor 2), and

Egoistic (factor 3). This structure is consistent with the literature that informed the survey creation. Biospheric, Social, and Egoistic Values scores were created by calculating the mean of the items included within each factor.

Table 1. Student Values: Summary of Principal Axis Factor Analysis Results.

	Rotated Factor Loadings		
	Biospheric Values	**Social Values**	**Egoistic Values**
Protecting natural resources	**0.88**	0.15	0.12
Preventing pollution	**0.82**	0.24	
Fitting in with nature	**0.73**	0.23	
Preserving nature	**0.71**	0.25	
Being in harmony with other living species	**0.61**	0.30	
Working for the welfare of others	0.27	**0.68**	
Correcting injustices locally or abroad	0.36	**0.65**	0.13
Caring for the weak	0.19	**0.64**	
Working for peace in the world	0.45	0.59	
Having an impact on people and events	0.16	**0.54**	0.16
Making sure everyone has equal opportunities	0.41	**0.53**	
Leading a group of people		**0.49**	0.39
Making a high salary in my field			**0.75**
Having the material possessions I choose			**0.64**
Having influence amongst my social group	0.11	0.42	**0.53**
Eigenvalues	3.50	2.92	1.48
% of variance	23.33%	19.45%	9.89%
Cronbach's α	0.89	0.81	0.68

Note: Factor loadings above 0.45 appear in bold. Items that loaded above 0.45 on more than one factor were eliminated.

The 28 Motivation items were also assessed via a principal axis factor analysis with varimax rotation. Subjects were asked the stem question of how "motivating each of the following statements" would be for encouraging the subject to participate in an activity. A five-factor solution with eigenvalues above 1 accounted for 60.267% of the variance. Three items ("Influence how society solves problems"; "See familiar faces"; and "Chance to have a leadership role") failed to load above 0.45 on any factor and were therefore eliminated when the new variables were created. Table 2 shows the factor loadings after rotation and the Cronbach's alpha for each factor. The items clustered under each factor represent the following categories of Motivations: Environmental Concern (factor 1), Self-interest (factor 2), Participate in Society (factor 3), Technology (factor 4), and Spirituality (factor 5).

Table 2. Student Motivations: Summary of Principal Axis Factor Analysis Results.

	Rotated Factor Loadings				
	Environmental Concern	**Self-Interest**	**Participate in Society**	**Technology**	**Spirituality**
Help restore natural areas	**0.88**	0.15	0.11	0.11	
Care for the land	**0.84**	0.21	0.15		0.11
Protect natural places from disappearing	**0.83**	0.23	0.16		
Make the environment better for others	**0.81**	0.26	0.19		
Consume a minimum amount of resources	**0.78**	0.12	0.19		0.28
Find ways to avoid waste	**0.69**	0.17	0.29	0.19	0.21
Learn about my surroundings	**0.62**	0.26	0.25	0.12	0.40
Use something borrowed or second-hand rather than buyin new	**0.57**	0.13	0.16		0.29
Do something that helps bring order to the world	**0.56**	0.40	0.24	0.10	0.12
Chance to be outdoors	**0.45**	0.15	0.36	0.10	0.18
Improve my outlook on life	0.28	**0.72**	0.29		0.16
Discover new things I'm not yet competent at doing	0.31	**0.60**	0.31	0.28	0.16
Do something that nobody else is doing	0.13	**0.57**	0.20	0.29	0.19
Make life more simple	0.28	**0.57**		0.22	0.21
Have a story to tell people		**0.48**	0.19	0.14	0.43
Opportunity to try something new	0.35	**0.45**	0.44		0.15
Influence how society solves problems	0.36	0.41	0.31	0.22	0.16
See familiar faces	0.16	0.39	0.29	0.19	
Chance to have a leadership role	0.24	0.38	0.34	0.13	0.16
Spend time for a good purpose	0.30	0.19	**0.79**		0.14
Meet new people		0.17	**0.71**		0.13
Learn new skills	0.19	0.19	**0.71**	0.23	0.15
Feel good about myself	0.19	0.43	**0.55**		
Help others do something important	0.32	0.42	**0.48**		0.18
Try out a new product or gadget	0.14	0.15	0.21	**0.91**	
Use the latest technology		0.33		**0.74**	
Chance to reflect	0.33	0.37	0.25		**0.65**
Contribute to my spirituality	0.21	0.21	0.18		**0.45**
Eigenvalues	6.19	3.69	3.54	1.88	1.57
% of variance	22.11%	13.17%	12.65%	6.73%	5.61%
Cronbach's α	0.94	0.86	0.86	0.85	0.67

Note: Factor loadings above 0.45 appear in bold. Items that loaded above 0.45 on more than one factor were eliminated.

2.5.2. RQ1: Personal Dimensions of Undergraduate ERBs

To assess the personal dimensions that predict undergraduate ERBs in on-campus residence halls, linear mixed effects regression models were used. As one of the major assumptions of linear models is the independence of the samples, Participant ID was entered as a nested random effect, along with Residence Hall, and University. This method

of analysis has been used in other published literature to explore the connections among multiple independent variables with a dependent variable where the samples are not entirely independent [45,46,63]. In the nested random effects model for Participant ID, Residence Hall, and University, the variables 'Residence Hall' and 'University' indicated no additional variance and were statistically close to zero; thus, the variables 'Residence Hall' and 'University' were eliminated. Three models were created: one for each outcome variable, corresponding to the three behavior categories (Energy, Water, and Materials). The models initially included fixed effects for the demographic variables: Gender, Major, Year in School, and Nationality. Age was not included in the model as it co-varied highly with Year in School, which was more relevant to predicting students' ERBs in on-campus residence halls. The model also included fixed effects of the categorical variables Survey Time (Fall or Spring) and Green Building (Green or Conventional), as well as the continuous variables: Biospheric Values, Social Values, Egoistic Values, Environmental Concern Motive, Self-interest Motive, Participate in Society Motive, Technology Motive, Spirituality Motive, Climate Change Awareness, Perceived Knowledge of Conservation Building Features, and Perceived Knowledge of Conservation Behaviors.

A process of variable selection was used to simplify the initial models. The first author removed variables one at a time according to the highest non-significant *p*-value and then compared the models based on the Bayesian Information Criterion (BIC), as models with lower BIC scores are considered more efficient and better fitting models [61]. The variable was removed from the model unless: (1) removal of the variable resulted in an increase in BIC score after elimination, or (2) if the variable with the next-highest non-significant *p*-value was relevant to the research questions. This process resulted in the elimination of the variable 'Nationality'. Most of the sample population were domestic students (94.4% domestic students), which resulted in minimal variability of 'Nationality'. The variable 'Year in School' was also eliminated from the Water Conservation and Energy Conservation behavior models.

2.5.3. RQ2: Analysis of Environmental Signage

The collection of photographs containing explicit environmental communications and behavioral prompts amounted to 73 images across the 6 residence halls. Researchers compiled a coding rubric (See Figure 1) that defined each of the values and motivations that had been identified through factor analysis, as well as three categories of information that are conducive to fostering ERB [17]. These definitions were used as a guide as each researcher identified the values, motivations, and informational frames communicated through text and images in the environmental prompts/signage. All 73 signage photos were coded by the secondary researcher. A subset of 30% (21 photos out of 73) of the photos was selected with a random number generator and coded by the primary researcher. Interrater reliability was assessed using Cohen's kappa coefficient, which was above 0.75 across all three dimensions, indicating "substantial" ($\kappa = 0.773$ for Motivations) and "almost perfect" ($\kappa = 0.897$ for Values; $\kappa = 0.905$ for Type of Information) level of agreement between the two researchers [62].

The final sample of photographs was reduced to eliminate signage redundancy, which was common since the six residence halls belonged to two university campuses, and buildings belonging to the same university typically employed consistent signage. The final sample included 25 unique pieces of signage or an average of 12 unique styles of signage per university. Though seemingly low, this number is consistent with observations by the primary researcher who has conducted signage studies in buildings on other university campuses. A sample of the types of environmental communications across all six residence halls can be seen in Figure 2.

Values

- **Biospheric:** Values that promote decision making towards protecting the environment, nature, and/ planet.
- **Social/Altruistic:** Values that promote decision making towards protecting the wellbeing of the society and community.
- **Egoistic Values:** Values that promote decision making towards benefit of self and facilitating personal interest, and social influence.

Motivations

- **Environmental Concern:** Motivation to protect natural environments, improve the environment for others, learn new relevant activities of personal stewardship (like minimizing waste, being outdoors).
- **Self-Interest:** Motivation to build competencies and have new experiences, improve outlook on life.
- **Participate in Society:** Motivation towards spending time for a good purpose, meeting new people, doing something important.
- **Technology:** Motivation to use the latest technology, equipment, and/or new products.
- **Spirituality:** Motivation to reflect and contribute to one's spirituality.

Type of Information

- **Declarative:** Information that provides facts, e.g., explains a process of an environmental system.
- **Procedural:** Information that explains how to achieve a particular conservation goal, e.g., identifying behavioral options, e.g., material sorting and recycling instructions.
- **Effectiveness:** Information that explains the measurable impact of different behaviors, e.g., refilling a reusable water bottle saves X amount of plastic from landfills.

Figure 1. Signage Coding Rubric.

Figure 2. *Cont.*

Figure 2. Examples of material, water, energy, and building sustainability-related signage.

3. Results

The data explored two research questions (RQs): What personal dimensions predict undergraduate Energy, Water, and Materials conservation behaviors within campus residence halls (RQ1)? Furthermore, does the language employed in environmental signage within residence halls align to the existing personal dimensions of undergraduate ERBs (RQ2)? Results pertaining to the personal dimensions of undergraduate ERBs in RQ1 are visible in Table 3. Results pertaining to the signage analysis in RQ2 are visible in Figure 3.

In total, 388 students took the survey in September of the fall semester (T1), and 187 students took the survey in March of the spring semester (T2), for a response rate of 23.6% and 11.4%, respectively. Fifty-four students took the survey at both T1 and T2, which necessitated the linear mixed effects regression method of analysis described in Section 2.5.2.

Students reported an average age of 19 years, ranging between 18 and 26 years old. Most students were first-year students (72.2%), though they ranged from first to fifth year. The sample consisted of 35.4% males, 62.6% females, and 1.9% gender-fluid or non-binary. Students reported majors belonging to the following academic fields: Social Sciences or Humanities (24.5%), STEM fields (74.1%), and environmental focus (4.1%). The sample was largely geographically homogenous, with 94.4% of participants from the United States and 5.6% international students.

Table 3. Personal Dimensions of Undergraduate Students' Environmentally Responsible Behavior–Linear Mixed Effects Regression Results.

		Energy Conservation Behavior			Water Conservation Behavior			Material Conservation Behavior		
	Variable	**Estimate**	***t*-Statistic**	***p*-Value**	**Estimate**	***t*-Statistic**	***p*-Value**	**Estimate**	***t*-Statistic**	***p*-Value**
	Intercept	2.055	2.312	0.022	3.302	5.958	0.000	3.852	6.080	0.000
	Social Science and Humanities Majors	0.170	0.734	0.463	−0.165	−0.733	0.464	−0.079	−0.386	0.699
	STEM/Business Majors	0.030	0.132	0.895	−0.140	−0.638	0.524	−0.030	−0.154	0.878
	Environmental Fields	0 [a]			0 [a]			0 [a]		
	1st Year	–	–	–	–	–	–	0.742	1.998	0.047 *
	2nd Year	–	–	–	–	–	–	0.690	1.850	0.066
	3rd Year	–	–	–	–	–	–	0.819	2.009	0.046 *
	4th Year	–	–	–	–	–	–	0.226	0.513	0.609
	5th+ Year	–	–	–	–	–	–	0 [a]		
Survey Time	Spring (Time 2)	0.110	1.401	0.163	0.161	2.316	0.022 *	0.162	2.641	0.009 **
	Fall (Time 1)	0 [a]			0 [a]			0 [a]		
Bldg. Type	Green	−0.126	−0.746	0.566	0.094	0.985	0.326	−0.072	−0.807	0.420
	Conventional	0 [a]			0 [a]			0 [a]		
Gender	Male	−0.205	−2.144	0.033 *	−0.184	−1.991	0.048 *	−0.303	−3.478	0.001 **
	Non-binary	0.235	0.639	0.523	0.172	0.500	0.617	0.034	0.107	0.915
	Female	0 [a]	.	.	0 [a]	.	.	0 [a]	.	.
Values	Biospheric	0.002	0.532	0.595	0.004	1.391	0.165	0.006	2.106	0.036 *
	Social	−0.001	−0.396	0.692	−0.003	−0.814	0.416	0.000	0.065	0.948
	Egoistic	−0.009	−3.310	0.001 **	−0.006	−2.285	0.023 *	−0.008	−3.618	0.000 ***

Table 3. *Cont.*

		Energy Conservation Behavior			Water Conservation Behavior			Material Conservation Behavior		
	Variable	**Estimate**	***t*-Statistic**	***p*-Value**	**Estimate**	***t*-Statistic**	***p*-Value**	**Estimate**	***t*-Statistic**	***p*-Value**
Motivations	Environmental Concern	0.005	1.397	0.163	0.008	2.129	0.034 *	0.007	2.092	0.037 *
	Self-interest	0.001	0.298	0.766	−0.002	−0.530	0.596	−0.002	−0.590	0.556
	Participate in Society	−0.001	−0.170	0.865	−0.009	−2.396	0.017 *	−0.004	−1.268	0.206
	Technology	0.005	2.359	0.019 *	−0.002	−0.943	0.347	0.006	3.259	0.001 **
	Spirituality	−0.001	−0.447	0.655	0.001	0.492	0.623	0.003	1.310	0.191
Knowledge	Climate Change Awareness	0.070	0.981	0.327	0.125	1.825	0.069	0.062	0.975	0.330
	Perceived Knowledge of Conservation Building Features	0.155	2.935	0.004 **	0.066	1.546	0.123	0.040	1.106	0.270
	Perceived Knowledge of Conservation Behaviors	0.009	0.166	0.868	0.039	0.732	0.465	0.032	0.716	0.474

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] Reference level; – Variable not included in model.

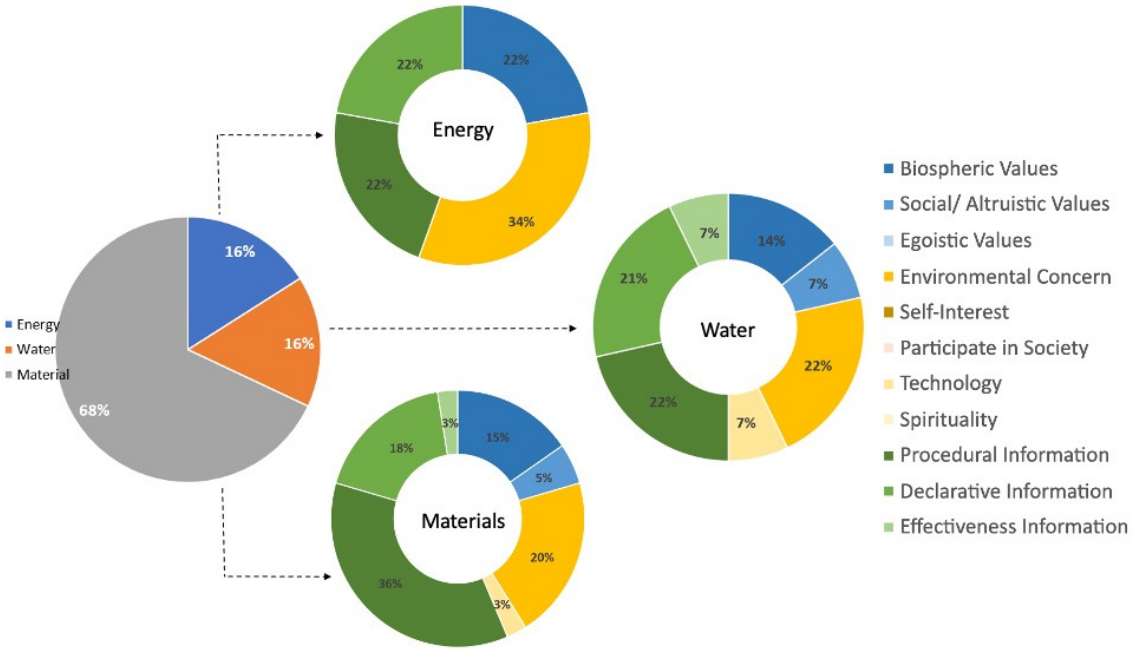

Figure 3. Frequency of signs appealing to energy, water, and materials behaviors, categorized by values, motivations, and informational frames employed in signage language.

3.1. RQ1: Personal Dimensions of Undergraduate ERBs

3.1.1. Values

Biospheric Values are significantly related to an increase in Materials conservation behavior, but not Energy or Water conservation. Increasing one point in Biospheric Values results in a 0.006 increase in Materials conservation ($\beta = 0.006$, $p < 0.05$). Egoistic values are significantly associated with poorer performance in all three conservation behaviors. For every one-point increase along the 0 to 100 values scale, Energy conservation behavior declines by 0.009 ($\beta = -0.009$, $p < 0.01$), Water conservation behavior declines by 0.006 ($\beta = -0.006$, $p < 0.05$), and Materials conservation behavior declines by 0.008 ($\beta = -0.008$, $p < 0.001$). There is no significant relationship between Social values and any of the three conservation behavior categories.

3.1.2. Motivations

The Environmental Concern motive significantly predicts improved Materials and Water conservation behaviors. Increasing one point in Environmental Concern results in 0.007 increase in Materials conservation ($\beta = 0.007$, $p < 0.05$) and 0.008 increase in Water conservation ($\beta = 0.008$, $p < 0.05$). The motivation to engage with Technology is significantly associated with higher Energy conservation scores ($\beta = 0.005$, $p < 0.05$) and Materials conservation behavior ($\beta = 0.006$, $p < 0.01$). The motivation to Participate in Society is significantly associated with poorer Water conservation behavior where every one-point increase on the 0 to 100 motivation scale predicts a 0.009 decline in Water conservation behavior ($\beta = -0.009$, $p < 0.05$). There is no significant relationship between motives of Self-interest or Spirituality and any of the three conservation behavior categories.

3.1.3. Knowledge

Of the Knowledge attributes surveyed, only students' Perceived Knowledge of Energy Conservation Building Features ($\beta = 0.168$, $p < 0.01$) is significantly associated with higher Energy conservation scores. Students' Climate Change Awareness and Perceived Awareness of Conservation Behaviors are not associated with any of the behavior categories.

3.1.4. Gender

Across all three behavior categories, Gender is a significant factor related to students' performance of ERBs. Male students perform significantly poorer Energy conservation behavior than female students ($\beta = -0.205$, $p < 0.05$), poorer Water conservation behavior than female students ($\beta = -0.184$, $p < 0.05$), and poorer Material conservation scores than female students ($\beta = -0.303$, $p < 0.01$). Levels of ERB performance by students identifying as non-binary did not differ from female students.

A cursory review of the data suggested that significant differences in ERB performance might be at least partially attributable to gendered differences in values and motivations. An Analysis of Variance (ANOVA) with post-hoc Tukey tests was performed to identify differences among males, females, and students identifying as non-binary with respect to Climate Change Awareness, the three values orientations (Biospheric, Social, Egoistic), and five motivational clusters (Environmental Concern, Self-concern, Participate in Society, Technology, and Spirituality) included in the study. The results reveal significant discrepancies between males and females that are consistent with the explanatory trends of these variables for predicting levels of ERBs. Students who identify as non-binary or gender fluid do not differ significantly from either males or females on any of the values and motivations measured in the study, with only one exception. Females reported their Motivation to Participate in Society to be an average of 20 points higher (on a scale of 1–100) than non-binary students ($p < 0.01$). However, only 6 students identifying as non-binary completed the survey items for the Participate in Society motivation compared to 257 females, and therefore the validity of this result is considered weak.

Given insubstantial differences between non-binary students and either males or females, the differences between males and females alone are reported in Table 4. Males report significantly lower Biospheric and Social values and lower motivation to participate in activities due to Environmental Concern, desire to Participate in Society and to engage in Spirituality. Conversely, male students report higher Egoistic values and are significantly more motivated by opportunities to interact with Technology than female students. Of these characteristics, Biospheric values and being motivated by Environmental Concern are both compatible with higher levels of ERBs in undergraduate students. Egoistic values, which are higher in male students, are significantly associated with poorer behavior across all three behavior categories. Though male students reported higher motivations to interact with Technology, which was positively associated with Energy and Material conservation behaviors, male student performance in these behavior categories was significantly lower than female students' behavior. The only value or motivation measured on which males do not significantly differ from females is the motive of Self-interest, suggesting that among undergraduate students, this motive is consistent across genders. Further, Self-interest was not significantly related to student performance of ERBs.

3.2. RQ2: Personal Dimensions Employed in Environmental Signage

Of the 25 unique pieces of signage offering environmental interpretation or behavioral prompts, most of the signage (68%) appeals to Material conservation behavior, with fewer examples of signage prompting Energy (22%) and Water (22%) conservation behaviors. Across Energy, Water, and Material conservation categories, behavioral messages are framed to appeal predominately to Biospheric values (14–22%) and the motive of Environmental Concern (20–34%). Less frequently articulated frames include Social values (5–7%) and the motive to engage with Technology (3–7%). No signage employed frames appealing to Egoistic values, motives of Self-Interest, Participation in Society, or enhancing Spirituality.

Procedural information was communicated in 22–36% of signage relating to Energy, Water, and Materials behaviors. For example, trash and recycling receptacles were frequently accompanied by instructional signage featuring textual and graphic directions on how to sort waste appropriately. Declarative information was provided in 18–22% of signage across all three behavior categories. Examples include factual statements related to the sustainability of building materials and fixtures. Signage employing Effectiveness

information was rare, only present in 3–7% of Materials and Water-related signage, and not at all in Energy signage. Examples of Effectiveness information include digital screens on water bottle filling stations that provide behavioral feedback, identifying how many plastic water bottles had been diverted from landfills, and signage above dual-flush toilets indicating that correct use results in 30% water savings.

Table 4. Gender differences in Values and Motivations.

		MALE		FEMALE			
	Variable	**M**	**SD**	**M**	**SD**	***t*-Test**	
Values	Biospheric	64.223	20.586	71.389	17.709	−3.419 **	+
	Social	59.908	19.191	68.071	15.503	−4.337 ***	
	Egoistic	67.089	17.191	61.206	19.263	2.856 **	-
Motivations	Environmental Concern	57.160	20.477	64.690	19.321	−3.425 **	+
	Self-Interest	65.026	20.541	68.547	17.478	−1.700	
	Participate in Society	69.566	17.348	76.127	15.074	−3.707 ***	-
	Technology	68.520	22.351	57.112	23.714	4.406 ***	+
	Spirituality	49.137	25.476	57.770	22.991	−3.221 **	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; M = Mean, SD = Standard Deviation; Values and Motivations range from 1 (lowest) to 100 (highest); + Vales/Motivations associated with significantly higher ERBs; - Values/Motivations associated with significantly lower ERBs.

4. Discussion

4.1. Framing Environmental Communications to Appeal to Undergraduates Living in Residence Halls

The analysis of signage revealed that material waste disposal signage (e.g., recycling, composting, refilling water bottles) was the most prevalent across the six residence halls, pointing to potential missed opportunities for relatively cost-effective behavioral interventions supporting energy and water conservation. Relying predominantly on language framed around Biospheric values and Environmental Concern, the results of this study suggest a broader range of values and motivations that might also connect to the undergraduate audience, including the motivation to engage with technology. Additionally, though the value of Egoism was significantly associated with poorer ERBs, particularly among college-aged males, no signage communicated environmental appeals with language that might appeal to male students' existing Egoism. Suggestions for crafting messages to appeal to the personal dimensions of undergraduate ERBs will be explored in more depth in the following sections. However, in brief, this research suggests ERBs are associated with multiple personal dimensions, including knowledge, values, motivations, and gender. Though this study did not test a statistical connection between signage frames and behavioral outcomes, educators and message designers may be informed by the dimensions identified through this work to "include multiple constructs" [63] in environmental communications in order to better appeal to specific populations.

4.2. Personal Dimensions of Undergraduate ERBs in Residence Halls

4.2.1. Knowledge

Of the Knowledge attributes surveyed, only students' Perceived Knowledge of Energy Conservation Building Features significantly predict higher Energy conservation scores. This relationship can possibly be explained by the fact that students who perform more energy-conscious behaviors are also more inclined to notice features in their environments that save energy, particularly where energy-saving features overlap with energy-saving behaviors, such as adjustable thermostats or blinds, or the decision to take the stairs instead of an elevator. This points to the importance of using different kinds of information in

environmental communications for supporting behavior change, as discussed in the work of Kaiser and Fuhrer [17]. For students who have noticed green building features and perhaps who are already motivated by environmental concern and biospheric values, two types of information would be useful to support energy-saving ERBs. Procedural information can guide students in how to use building features to save energy, and effectiveness information can detail the relative energy savings of different behavioral options. However, overall, knowledge was not a significant predictor of students' ERBs in this sample, which is consistent with the findings of Kirby [64]. This could be attributable to there being very little variation among students' knowledge of climate change and perceived awareness of ERBs.

4.2.2. Values

Of the three values included in the model, Egoistic values are consistently associated with lower ERBs, and this relationship is significant across Energy, Water, and Materials behaviors. The Egoistic value cluster is composed of items emphasizing one's ability to earn a high salary, acquire desired material possessions, and have influence among one's social group. Though this study did not explore why Egoistic values appear to be inconsistent with ERBs, one possibility may be the assumption that environmental stewardship involves self-sacrifice or abandonment of egoistic values. Yet, recent work suggests that happiness, or subjective well-being, can be compatible with ecological well-being [64,65].

Environmental messaging in this study was predominantly framed according to Biospheric values. Perhaps messages in the environment may also be tailored to appeal to Egoistic values while successfully aligning to environmental stewardship goals. For undergraduate students, framing environmental issues and behaviors to appeal to Egoistic values may involve highlighting the co-benefits of personal and planetary well-being. At the curricular or programmatic level, diverse fields of study may feature economically viable professions and satisfying leisure activities that address environmental issues. Within the built environment, environmental messaging connecting students' behavior with environmental outcomes can also be framed to appeal to Egoistic values, in addition to the Biospheric values that are commonly employed throughout residence halls. Figure 4 below shows an example of signage added to a paper towel dispenser in the bathroom. The text urges users to air dry their hands instead of using paper towels to "save our natural resources." While Biospheric values did positively support Materials/Waste conservation behavior ($\alpha = 0.006$, $p < 0.05$), the language could be amended to also appeal to students' existing Egoistic values. A personally relevant frame for students in the Midwest that appeals to both Biospheric and Egoistic values might state, "Please consider using the hand dryer instead of paper towels–Save our natural resources and enjoy many more years of weekends in the North Woods!" Future research should explore the efficacy of signage and environmental, behavioral prompts that frame messages to appeal to Egoistic values.

4.2.3. Motivations

Environmental Concern emerges as a broad yet highly coherent ($\alpha = 0.938$) motivation for undergraduate students in this study. Items in this factor include traditional environmental stewardship behaviors (e.g., help restore natural areas, care for the land, protect natural places from disappearing), as well as motivations to improve the environment for the benefit of others and to explore new, personally relevant, aspects of environmental stewardship (e.g., find new ways to avoid waste, learn about one's surroundings, chance to be outdoors). This environmentally driven yet curious motivation to participate in activities to benefit the environment suggests students associate multiple embedded benefits with time spent outdoors and, specifically, doing activities that have a significant impact on the natural world.

Environmental Concern significantly predicts improved behavior with respect to Water conservation and Materials conservation. However, Environmental Concern does not appear to be associated with students' reported Energy behaviors. One possible

explanation for this discrepancy is the degree to which different suites of behavior actively connect with one's conception of the natural world. Actions involving water and material disposal involve a tangible connection between person and resource. Water can easily be seen, felt, heard, and tasted. Materials and waste are objects that invite a behavioral response–to be picked up, to be organized, to be disposed of. In activities that consume energy, the resource being consumed is intangible. When turning on a light, one only sees the product of the resource in use; one does not actually see the electrons coursing through the wires or the fossil fuels being burned in their activation. Energy is largely invisible [66]. Signage that creatively draws attention to behaviors that consume energy may be one possibility for connecting students' Environmental Concern motivation to their energy behaviors.

Figure 4. Signage uses Biospheric value frame ("Save our natural resources") to promote air drying hands instead of paper towel usage.

Students motivated by opportunities to engage with Technology report greater Energy and Materials/Waste conservation behaviors. These results suggest that enhancing students' exposure to technology related to energy and resource conservation in residence halls may be effective for improving their ERB overall. For all students, opportunities to use technology and gadgets may entice additional participation in ERBs, as students are drawn to explore the technology and discover satisfaction in participating in the behavior. While many green buildings are increasingly shifting toward automated functions, students may require an additional sense of control and exploration. Applications may include not only operable light switches but dimmers, various forms of energy feedback technology, programmable thermostats, shower meters and timers, and trash and recycling compactors. Signage that informs people of available conservation technology and frames using these features to engage with technology could be an effective way to promote ERB. Future research may test the efficacy of signage employing this and other motivational frames.

4.2.4. Gender

Males consistently report lower ERBs than females, and these differences are significant across Energy, Water, and Materials behavior. Evidence of gender differences with respect to ERBs is consistent with findings reported in other empirical studies [67–71]. However, the reason for gender differences underlying divergent environmental behaviors is unclear. Though Stern et al. [68] suggest that gender differences with respect to environmental actions are not due to any inherent disparities in the values held by females and males, the results of this study suggest the contrary.

Together, these results shed light on some of the possible explanations underlying the poorer performance of ERBs by males in undergraduate residence halls. Two traits are particularly worthy of focus: Egoistic values and the motive to engage with Technology. Males report significantly higher scores than females on both characteristics. While Egoistic values have been consistently associated with lower levels of ERB, the environment may be adapted (as previously described) to better support desirable behavior by successfully leveraging existing Egoistic values. The Egoistic value cluster is composed of items emphasizing one's ability to earn a high salary, acquire desired material possessions, and have influence among one's social group. This value cluster is particularly well-aligned to traditional gender norms about male responsibility to be the "breadwinner" or provider. While contemporary college students may not overtly identify with these gender norms, gender expectations nonetheless may explain the difference between males and females with respect to Egoistic values. Additionally, males are significantly more motivated than females by opportunities to use new technology or try new products. This motive to interact with Technology also significantly predicts improved Energy behavior and Materials/Waste behavior. Yet despite having a more favorable disposition toward technology, males report significantly poorer behavior in each of these behavior categories. Thus, providing more opportunities for students, and males, in particular, to interact with technology or gadgets in the pursuit of conserving energy and resources may be effective for improving ERBs overall. Du and Pan suggest understanding gender differences in conservation behaviors can greatly support ERBs in single-gender housing [72], as is common among undergraduate students living in on-campus housing.

4.3. Limitations

This study investigated the personal dimensions of college students' environmental behaviors, including values, motivations, knowledge, and gender [73–76]. However, the literature is clear that behavior is shaped by multiple factors beyond these psychological and cognitive dimensions [14,23,24,77]. Beyond the scope of this study was a consideration of how the social environment of inhabiting a residence hall might contribute to students' ERBs. Living in highly communal settings such as residence halls, students were likely influenced by the visible behaviors of valued peers, as has been demonstrated in other research [78]. Within the context of this case study, social values were rarely used to frame behavioral appeals. Future research should explore the impact of social norms on students' behavior using social norm messaging in building signage.

The methodology used in this study relied on self-report data about individual behaviors. The researchers attempted to minimize social desirability bias by distributing the survey online and collecting no personal identifiers. Future behavior measures could be more robust by including observations, collecting energy and resource consumption data at the building or floor level, or having participants keep behavior logs.

Additionally, while it would be ideal to randomly assign incoming students to various residence halls, unfortunately, most first-year residents were able to self-select the residence hall in which they would reside. This self-selection might have affected the findings, with students who selected green residence halls being previously primed to adopt environmentally responsible behavior. To address this possibility, an analysis of variance was conducted examining the T1 survey data by the residence hall. Post-hoc Tukey tests revealed that across all T1 survey instrument measures, there was only a single

statistically significant difference. Students in building B.1 reported significantly lower motivation to Participate in Society (M = 68.41, SD = 17.56) than students in B.2 (M = 77.19, SD = 13.13); t(122) = −3.069, $p = 0.003$. While this does not eliminate the possibility that self-selection affected the findings reported here, it does reduce that prospect.

5. Conclusions

Promoting durable environmentally responsible behavior necessitates addressing a combination of situational, psychological, and social factors. Better understanding the values and motivations associated with environmental behaviors is the first step in crafting effective behavioral interventions. The findings of this study suggest several specific factors (e.g., Biospheric values, Environmental Concern motive, Technology motive, Egoistic values, and Gender) that significantly shape environmentally responsible behaviors in the context of the on-campus college student. Understanding these factors can help behavior change professionals to craft more impactful behavioral interventions that "speak to" the salient dimensions associated with environmental behaviors.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14042025/s1, survey: Cognitive and Behavioral Affordances of Stewardship in Green Built Environments.

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